CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-38

November 9, 1977

1. Name of fault: Chino fault.

2. Location of fault: The Chino fault forms the approximate northeastern boundary of the Puente Hills and the northernmost Santa Ana Mountains, within the Corona North, Prado Dam, and Corona South quadrangles (figures 4a, 4b, and 4c).

3. Reason for evaluation: This fault is located within the 1977 study area of the 10-year program for fault evaluation.

4. List of references:

California Department of Water Resources, 1970, Meeting water demands in the Chino-Riverside area: California Department of Water Resources Bulletin 104-3, Appendix A: Water Supply, 108 pages. Map scale 1:127,000.

(Very generalized mapping of the fault, nothing useful said about the fault in the text.)

Durham, D.L., and R.F. Yerkes, 1964, Geology and oil resources of the eastern Puente Hills area, southern California: U.S. Geological Survey Professional Paper 420-B, 52 pages. Map scale 1:24,000.

(This is the most detailed mapping of the northwestern half of the fault, and the text has the most detailed discussion of that part of the fault.)

Eckis, Rollin, 1934, South coastal basin investigation, geology and ground water storage capacity of valley fill: California Division of Water Resources Bulletin 45, 279 pages. Maps A, C, and E. Scale about 1:150,000.

(Shows the Chino fault extending northwest, as an inferred buried fault, almost to the San Jose fault, but gives no description of the fault in the text.)

English, W.A., 1926, Geology and oil resources of the Puente Hills region, southern California: U.S. Geological Survey Bulletin 768, 110 pages. Map scale 1:62,500.

(He gives a general discussion of the stratigraphy and structure of the region, but provides no specific descriptions of the faults.)

Fife, D.L., D.A., Rodgers, G.W. Chase, R.H. Chapman, and D.C. Sprotte, 1976, Geologic hazards in southwestern San Bernardino County, California: California Division of Mines and Geology Special Report 113, 40 pages. Map scale 1:48,000.

(Their mapping of the Chino fault is taken from Durham and Yerkes (1964). They say nothing about the fault in their text.)

Garrett, A.A., and H.G. Thomasson, Jr., 1949, Ground water outflow from the Chino basin, California, and the controlling geologic and hydrologic conditions: U.S. Geological Survey Open-File Report. (Only the geologic map, plate 102, available). Map scale 1:62,500.

(Shows Chino fault in a very general way; of no value to this investigation.)

Gray, C.H., Jr., 1961, Geology of the Corona South quadrangle and the Santa Ana Narrows area, Riverside, Orange, and San Bernardino Counties, California: California Division of Mines Bulletin 178, 120 pages. Map scale 1:24,000.

(He discusses scarps along the Chino fault between Mabey and Joseph Canyons, but shows only a dotted (buried) fault symbol along that section of the fault.)

Jennings, C.W., 1975, Fault Map of California with locations of volcanoes, thermal springs and thermal wells: California Division of Mines and Geology, California Geologic Data Map Series, Map no. 1. Map scale 1:750,000.

Lamar, D.L., 1959, Geology of the Corona area, Orange, Riverside and San Bernardino Counties, California: unpublished masters thesis, University of California, Los Angeles, 95 p. Map scale 1:12,000.

(The mapping was accomplished with only 60 days fieldwork, and is quite generalized. He provides some useful discussion of the fault.)

Olson, L.J., 1977, Mahala oil field and vicinity: California Division of Oil and Gas Report no. TR 18, 14 pages.

(Mapping not useful. He says (p. 7) there has been no movement along the Chino fault during Holocene time.)

Real, C.R., D.L. Parke, and T.R. Toppozada, 1977, Magnetic tape catalog of California earthquakes, 1900-1974: California Division of Mines and Geology.

Scullin, C.M., 1977, Engineering geologic-seismic evaluation and feasibility of development, lots 1-15, tract 7219, Rancho Corona Drive, Riverside County, California: unpublished consultants report with addendum. Map scale 1:24,000.

(Discusses trenching across a supposed trace of the Chino fault, but the trenches (5 to 9 feet deep) showed no evidence for the existence of the fault.)

Weber, F.H., 1977, Seismic hazards related to geologic factors, Elsinore and Chino fault zones, northwestern Riverside County, California: California Division of Mines and Geology Open File Report 77-4 LA, 96 pages. Map scale 1:24,000.

(This is the most detailed study of the southeastern half of the Chino fault and the related faults at the northern end of the Elsinore fault. This is also the only study where the determination of recency of fault activity was a significant consideration.)

Woodford, A.O., J.S. Shelton, and M.G. Moran, 1944, Stratigraphy and oil possibilities of Puente and San Jose Hills, California: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 23. Scale 1:75,000.

(They show only a solid-line symbol for the Chino fault -- on a poor base map. There is a brief discussion of the fault on the map sheet.)

5. <u>Summary of available data:</u>

<u>Chino fault, northwest of the Santa Ana River:</u>

This part of the Chino fault trends N 38°-40° W along the northeastern margin of the Puente Hills (figure 4b). The fault has, or is presumed to have, a surface trace where Tertiary sedimentary rock is exposed at the surface. To the northwest, beyond the community of Los Serranos, the fault is covered by both younger and older alluvium, and is not mapped by any of the workers except Eckis (1934). He shows it as an inferred buried fault extending northwestward almost to the San Jose Hills, but provides no basis for extending the fault that far.

California Department of Water Resources (1970, p. 10) says " ... its northern terminus is not known..." Most of the references extend the fault as a buried feature, southeastward across the Prado flood control basin. Weber (1977), however, shows a dashed fault through older alluvium, and says (p. 41), " ... fault traces are clearly expressed in older and slightly older alluvium ... between the hills (Puente Hills) and the Santa Ana River bed on photographs taken in 1939, before completion of Prado Dam ..."

Regarding the nature of the surface trace, Durham and Yerkes (1964, p. 32) say, "The trace of the fault is usually poorly exposed and is characteristically marked by a zone of contorted and crumpled siltstone on the southwest side that has been crushed against more resistant pebbly sandstone and conglomerate on the northeast side." These rocks are both part of the Puente Formation, with middle to upper strata of the formation on the southwest side, and only upper strata of the formation on the northeast side. They add, "The best exposure of the Chino fault is in the cuts made for State Route 71 at the easternmost tip of the hills ..." Lamar (1959, p. 69) says, "There are no stream offsets along the fault trace." Weber (1977, p. 42), however, says, "Relative youthfulness of activity along the fault zone in the Puente Hills is attested to by right-deflected drainages and apparent offset of older alluvium and relic, reddish-brown duricrust paleosol ..."

Regarding the attitude of the fault, the fault dips steeply to the southwest with stated angles ranging from 50° to 65° . On the basis of oil well data, Durham and Yerkes (1964, p. 33) say that the fault maintains a dip of 59° to 67° to a depth of at least 2575 feet below sea level. Olson (1977, p. 7) says, "Near the surface, the fault dips about 50 degrees to the southwest, and the dip gradually steepens with depth."

The southwest side of the fault is upthrown. For that part of the Chino fault that passes through the exposed Puente Hills, Durham and Yerkes (1964, p. 33) say,"The stratigraphic separation across the Chino fault in the central part of its exposure is about 1,200 feet ..." and, "... at the southern end of its exposure is about 2,400 feet ..." They also say that the attitudes of the axes of plunge folds suggest a component of lateral movement along the fault, but they do not say what the sense of lateral movement was.

None of the references state or imply that there has been Holocene offset along this part of the Chino fault. Only three writers discuss the timing of movement along the fault. Durham and Yerkes (1964, p. 34) say:

> The youngest strata cut by the Chino fault are assigned to the Sycamore Canyon member of the Puente Formation of late Miocene age, although the uppermost part of this unit may include strata of Pliocene age. Alluvial deposits are not disturbed by the fault. Movement along the Chino fault probably followed formation of the Mahala anticline and probably coincides with or followed the middle Pleistocene deformation of the Los Angeles basin.

Olson (1977, p. 7) says, "Movement along the Chino fault probably took place during Pleistocene time. Alluvial deposits are not disturbed by the fault, indicating no movement during Holocene time." Weber (1977, p. 41), however, suggests that displacement may have been nearly as recetn as Holocene. He says that "slightly older alluvium" between the Puente Hills and the Santa Ana River is clearly faulted in 1939 photographs. However, he shows the fault as dashed and queried on his map. Apparently, subsequent to 1939, these features have been destroyed by water impoundment behind Prado Dam.

Chino fault southeast of the Santa Ana River:

To the southeast of the Santa Ana River, the Chino fault continues in about a S 40° E direction and converges with the complex Elsinore fault zone somewhere between Main Street Canyon and Bedford Canyon (figures 4a, 4b, and 4c). Only three people have prepared large scale maps of this part of the Chino fault (Lamar, 1959; Gray, 1961; and Weber, 1977), but there is much disparity among them in their location of the fault and the evidence they use. Lamar (1959, p. 70) says, "It has been assumed that the fault is located at a rather indistinct topographic break marking the approximate northeast edge of stream deposits." He is not clear about the location and extent of this topographic feature.

Gray (1961, p. 47) says:

> Southeast of the Puente-Chino Hills the fault is largely or wholly hidden beneath alluvium, but its projected course appears to gradually converge upon and to perhaps eventually join the Elsinore fault. Sharp differences in groundwater levels in water wells on La Sierra Stock Ranch near State Highway 18, as well as topographic features (chiefly anomalous, narrow trenches) indicate that the fault may cross the Santa Ana River and extend southeast of Highway 18 along the first major wash cut in the older alluvium east of Wardlow Wash. Farther southeast, along the margin of the Santa Ana Mountains, the chief evidence for the Chino fault is topographic. A well-defined scarp at the contact between terrace deposits and older alluvium may be the surface expression of the Chino fault. Its trace also may coincide with anomalous scarplets and benches, especially between Mabey and Main Street Canyons, and with offset drainage lines in the streams between Main Street and Joseph Canyons. The southeastward projection of the trace of the Chino fault from its easternmost exposure in the Puente-Chino Hills suggests that the Chino fault joins one of the faults parallel to the Elsinore fault west of Bedford Canyon and thence joins the Elsinore fault between Bedford and Brown Canyons.

Weber (1977, p. 42) says:

> Southeast of the Santa Ana River, a prominent northeast-facing, modified scarp occurs between Paseo Grande and Avenida del Vista (photo 13; LQ-7, plate 2a); and an apparent modified scarp lies at the foot of Lincoln Avenue, with older alluvium displaced upward to the southwest (VQ-12, plate 2a). From Lincoln Avenue northwestward the projection extends along Wardlow Wash, from where older alluvial fan deposits apparently are displaced upward to the southwest (Qofu) relatively to the northeast (Qof). Between the Riverside Freeway and the Santa Ana River, however, similar displacement of older floodplain deposits (Qov) is shown only very tentatively; no clear trace of the fault exists here, nor across the Santa Ana River bed, as interpreted from the pre-Prado Dam aerial photographs.
>
> The trace of the Chino fault between the Santa Ana River and the intersection of Chase Drive and Lincoln Avenue, southwest of Corona, is mapped slightly differently for this report than by Gray (1961, plates 1 and 3). Gray shows the fault to bow to the northeast about one-half mile (0.3 km), partly on the basis of differences in elevation of water in wells and partly on the belief that the fault trace extends along the bottom of a linear canyon south of the freeway. Perhaps the position of the fault trace as mapped by Gray (1961) through this area represents a second, parallel fault, equivalent to the Sardco fault of Gaede (1969) and the Division of Oil and Gas (1974).

Scullin (1977) conducted exploratory trenching across the location of Weber's (1977) inferred fault along Wardlow Wash (see figure 4c).

Scullin recognized three lithological units in this area: topsoil, recent alluvium, and older alluvium. Most of his trenches penetrated into older alluvium (according to his trench logs), but about 25 percent penetrated only into younger alluvium. The trenches, ranging from five feet to nine feet in depth, yielded no evidence of faulting.

All of the workers either state or imply that the sense of movement along the southeastern half of the Chino fault is the same as the northwestern half: reverse movement with the southwestern side upthrown. Lamar (1959, p. 70) says, on the basis of gravity data, that the fault dips 50° to 65° southwest and has undergone about 5500 feet (1700m) of vertical offset.

Regarding recency of faulting, Gray (1961, p. 49) says that the geomorphic features along the fault indicate the movement has continued into "Recent" time. Weber (1977, p. 42, 45) applies the expressions "relative youthfulness of activity", "relatively recent faulting", and "relatively youthful faulting" in interpreting various features along the fault. He does not define these expressions. On his plate 2A, he annotates one part of the fault, where it crosses Mangular Avenue, as having had Holocene activity. Lamar (1959) says nothing about the question of recency of his text, and, on his map, shows none of the faults cutting young alluvium.

Seismicity:

The "A" quality data (figure 3a) show no distribution patterns or large magnitude single events associated with the Chino fault. The "B" quality data (figure 3b) show a weakly linear pattern of epicenters extending northwesterly from the area of convergence of the Chino, Whittier, and Elsinore faults. Since both the Chino and Whittier faults dip toward each other, the epicenters (5 km accuracy of location) could represent events on either fault.

6. Interpretation of aerial photography: None.

7. Field observations: None.

8. Conclusions:

Regarding the northwestern half of the Chino fault, none of the workers state or imply Holocene activity. Weber (1977, p. 42) discusses the "relative youthfulness of activity" along this part of the Chino fault. He doesn't define this term, or the several variations of it that he uses elsewhere, but the contexts of his usages indicate that he means late Quaternary, and not necessarily Holocene activity. The references are not clear as to how well defined the fault is. It is well defined in some roadcut exposures within the Tertiary rock terrane, within the Puente Hills, but elsewhere it is apparently difficult to locate the trace. The compilation of various maps of the fault (figure 4b) shows relatively good agreement about the location of this part of the Chino fault.

By comparison, there is poor agreement about the location of the southeastern half of the Chino fault. It seems probable that much of this part of the fault is not well-defined. Both Gray (1961, p. 49) and Weber (1977, plate 2A) indicate their belief that this part of the fault has been active during Holocene time. They are not at all specific about their evidence, however, so I harbor doubts about their conclusions.

Based on the literature, there is no conclusive data to indicate that the southern segment of the Chino fault is either "sufficiently active" or "well-defined". The northern segment appears to be reasonably well-defined, but shows no hard evidence of Holocene activity.

9. Recommendations:

At this time, I feel that the best course of action would be to go onto that area with Hal Weber and get him to show me (us) his best evidence for Holocene activity. If that does not lead to a conclusive decision, one way or another, on our part, then I would have to conduct some independent aerial photo and ground studies. At this time I can not recommend any specific sizes or locations for special studies zones.

10. Investigating geologist's name and date:

Drew P. Smith

DREW P. SMITH
Geologist
9 November 1977

I recommend against zoning based on the evidence presented. Additional field and photo work is given a moderate priority. If such work reveals Holocene faulting, then additional recommendations are in order. EWH 12/16/77

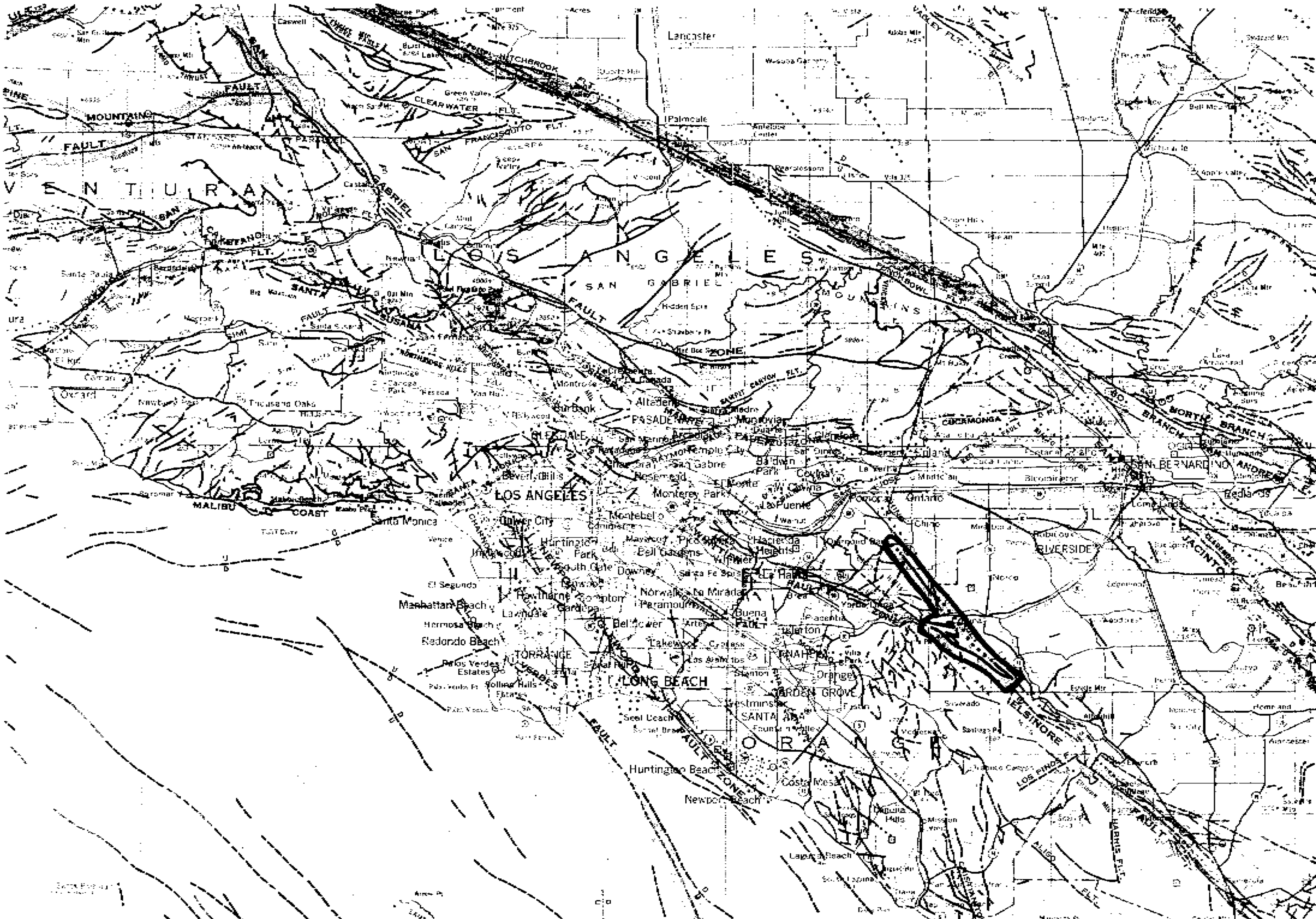

Figure 1. Index map showing location of the Chino and related faults. Map is modified from Jennings (1975).

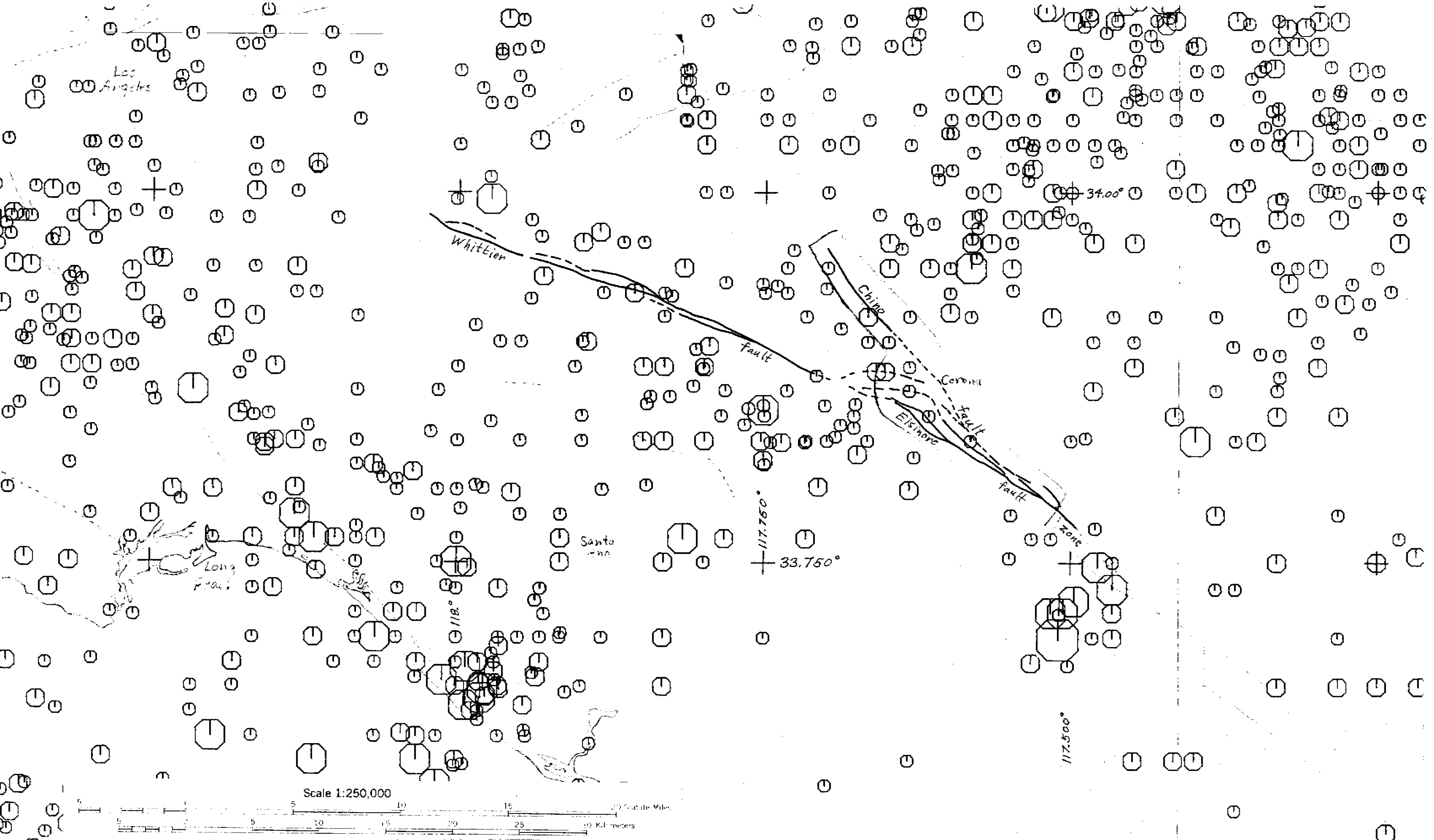

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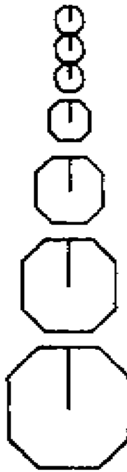
Figure 3b. Seismicity in the vicinity of the Chino, Elsinore, and Whittier faults. "B" quality epicenter plots from Real et al (1977).

EPICENTERS IN THE L. A. AREA, B QUALITY

TRANSVERSE MERCATOR PROJECTION

SCALE = 1/250000

MAGNITUDE



..... 0.0 TO 0.9
..... 1.0 TO 1.9
..... 2.0 TO 2.9
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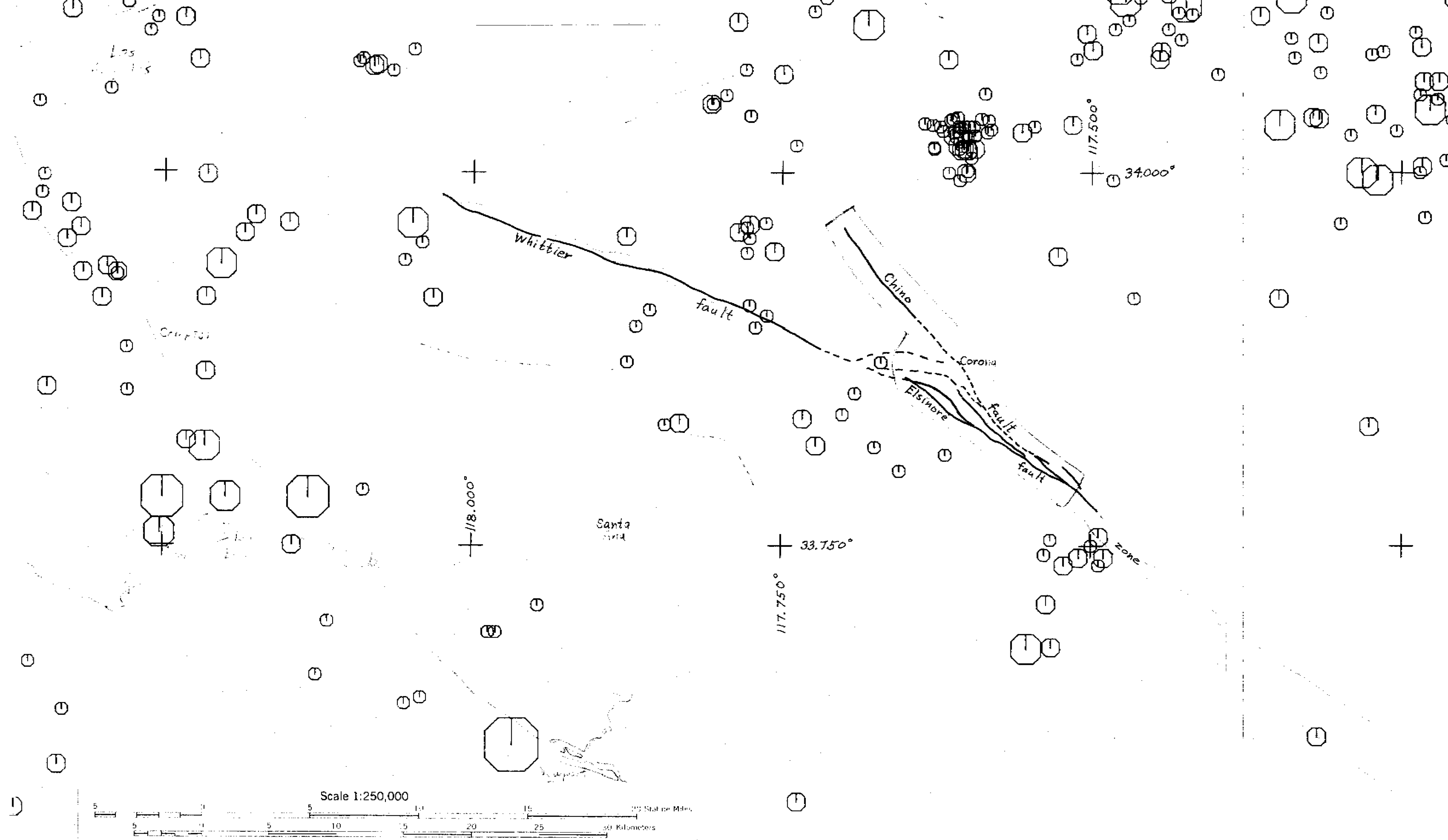

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Figure 3a. Seismicity in the vicinity of the Chino, Elsinore, and Whittier faults. "A" quality epicenter plots, from Real et al (1977).

EPICENTERS IN THE L. A. AREA, A QUALITY

TRANSVERSE MERCATOR PROJECTION

SCALE = 1/250000

MAGNITUDE

..... 1.0 TO 1.9
..... 2.0 TO 2.9
..... 3.0 TO 3.9
..... 4.0 TO 4.9
..... 5.0 TO 5.9
..... 6.0 TO 6.9